Acute effects of an *Avena sativa* herb extract on responses to the Stroop colour word test.

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Short title: Effect of oat extract on Stroop Test

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Abstract

Background and aims: Extracts from oat (*Avena Sativa)* herb may benefit cognitive performance. This study investigated whether Neuravena®, an oat herb extract, could acutely improve responses to the Stroop Colour-Word test, a measure of attention and concentration and the ability to maintain task focus.

Subjects and Methods: Elderly volunteers with below average cognitive performance consumed single doses (0, 1600 and 2400 mg) of oat herb extract at weekly intervals in a double-blind, randomized cross-over comparison;. Resting blood pressure (BP) was assessed before and after supplementation and a Stroop test was performed.

Results: Significantly fewer errors were made during the colour naming component of the Stroop test after consuming the 1600 mg dose than after the 0 mg or 2400 mg doses (F (1,36) = 18.85, P<.001). In 7 subjects with suspected cognitive impairment, Stroop interference score was also improved by the 1600 mg dose compared to 0 and 2400 mg doses (F (1,34) = 2.40, P < .01). Resting BP was unaffected by supplementation.

Conclusion: Taking 1600 mg of oat herb extract may acutely improve attention and concentration and the ability to maintain task focus in older adults with differing levels of cognitive status.

Introduction

Avena sativa (oat) herb, in its various forms and extracts, has been traditionally known for its physical and psychological fortifying properties. Proposed beneficial effects include: reduced risk of heart disease, reduced depressive symptoms, raised energy levels, increased ability to cope with stress, reduced anxiety, and increased physical performance [1, 2]. However, many of these benefits are yet to be substantiated by rigorous scientific enquiry [2].

Studies in rodents have shown that an oat herb extract, Neuravena® (EFLA® 955) can increase learning ability and mental alertness. Schellekens et al 2009 [3] investigated the effect of supplementing rat diets for seven weeks with either 10 or 100 g/kg of body weight/day of Neuravena®. This study demonstrated that a dose of 10 g/kg of body weight/day improved general learning performance, seemingly due to enhanced alertness and improved stress coping abilities, pro-social behaviour and enhanced mood, suggesting the extract could support active rather than passive stress coping behaviour.

In humans, a single 2500 mg dose of Neuravena® was found to decrease delta and theta electrical brain wave activity and increase alpha2 wave activity [4], effects consistent with increased mental alertness.

The current study aimed to explore the effects of oral Neuravena® on concentration and alertness, using the Stroop colour-word test in older adults with below average cognitive function, and to determine whether any observed effects were dose-dependent.

Materials and Methods

The study was approved by the University of South Australia's Human Research Ethics committee and volunteers provided written, informed consent prior to commencing the trial. This trial was registered on the Australia and New Zealand Clinical trials register ACTRN12609000140257.

Participants

One hundred and eighty five volunteers were screened at the Nutritional Physiology Research Centre, Adelaide for inclusion in the study. Volunteers were recruited if they were aged 50 years or above, healthy, not taking medications or supplements likely to affect the outcome of the study and assessed as having below average cognitive performance (DemTect® score between 9-16 points[5]. Of those screened, 36 subjects met the selection criteria and completed the trial.

Supplements

Neuravena® (wild green oat extract EFLA® 955) was obtained from Frutarom Switzerland Ltd and was manufactured using green, rapidly dried, aerial parts of *Avena sativa* L., harvested just before it is in full flower. It is a dry powder comprising an ethanol (30% w/w) extract of the above ground (green) parts of a selected variety of *Avena sativa* (3.5:1 concentration), dispensed as 400mg capsules together with 28% (w/w) Maltodextrinum Ph.Eur. as a carrier and 2% (w/w) silica colloidalis anhydrica Ph.Eur.

Participants were allocated to consume each of two doses of Neuravena® (1600 and 2400mg) and a placebo (0mg) (containing an inert filler and matched for appearance) at weekly intervals in a double-blind, randomized crossover comparison.

Procedure

On the first visit volunteers underwent cognitive screening using the DemTect® which is a screening tool used to identify Mild Cognitive Impairment (MCI) and early signs of dementia. Scores from 0-8 represent suspected dementia, 9-12 represent suspect MCI and 13-18 represent normal cognitive performance. The median score in the current sample was 16 which was also found by Kalbe et al., (2004). Participants with below average cognitive

performance but without suspected dementia (scores ranging from 9 to 16) were included in the current study.

All subsequent visits were conducted on the same day of the week at the same time with a one-week washout between each session. All participants were instructed to fast for four hours before each session. On arrival resting supine blood pressure (BP) was measured following international guidelines [6]. Following this volunteers consumed an oral supplement (0, 1600 or 2400 mg of Neuravena® in random order) with a glass of water and 1-2 hours later the BP measurement was repeated and a Stroop Colour Word test[7] was performed. This test is designed to assess focussed attention and the ability to suppress task-irrelevant, habitual responses. During the test participants were given a sheet of colour names printed in incongruent coloured ink (for example, the word "blue" is printed in red ink). In the first trial, participants were asked to read all the words as fast and accurately as possible. In the second trial participants were asked to name the colour of each word, ignoring the word name itself. A measure of the Stroop interference effect was calculated using the ratio of the time taken to name colours divided by the time taken to read words. Numbers of corrected and uncorrected errors for each trial were also recorded. Therefore, higher scores on all metrics reflect poorer performance.

Statistical Analyses

One way repeated measures analysis of variance (ANOVA) was conducted on the responses to the Stroop test using dose as the within-subjects factor using Statistical Package for the Social Sciences (SPSS) version 18 (Chicago, Illinois, United States of America). Fixed effects two-way ANOVAs were also conducted on outcomes including both dose and MCI status as factors. Where significant main effects were detected means were compared *post hoc* using a Bonferroni test. To produce the MCI status factor, subjects were grouped according to their DemTect® score. Seven participants scoring 9-12 were allocated to the

suspected MCI group; the remaining 29 participants scoring 12-16 were allocated to the non-MCI group.

Results

Of the 36 subjects who completed the trial there were 22 females and 14 males with a mean age of 67 ± 8.6 years, mean DEMTECT score 14 ± 2, BMI 26.9 ± 3.8 kg/m^2, systolic blood pressure 127 ± 19.2 mmHg, diastolic blood pressure 72.0 ± 7.5 mmHg and heart rate was 63.0 ± 8.6 bpm. There were no significant treatment effects on clinic BP measures.

The intervention results indicated a significant main effect of dose of oat herb extract, F (1, 34) = 6.97, $P < .05$, and a dose x MCI status interaction, F (1,34) = 2.40, $P < .01$ on the Stroop interference score. Means and standard errors appear in Table 1.

Those who were suspected to have probable MCI performed significantly better on the Stroop test (lower interference scores represent better performance) after taking the 1600 mg dose of supplement than after taking 0 mg or 2400 mg.

There was also a main effect of dose for the number of errors made during the colour naming trial of the Stroop test, F (1,36) = 18.85, $P<.001$. However, there was no dose x MCI status interaction. Descriptive statistics appear in Table 2. There was a similar pattern of effect for all participants, regardless of MCI status, with significantly fewer errors made after consuming the 1600 mg supplement dose than after consuming the 0 mg or 2400 mg doses.

Discussion

This study demonstrated that acute supplementation with the oat herb extract could significantly improve the response to the Stroop Colour-Word test in people with lower cognitive status The Stroop test requires participants to inhibit a habitual response to reading colour names in order to name the colour in which they are printed. As such, high performance on this task, reflected in lower interference scores, represents high levels of

attention, concentration and task focus. It appears that 1600 mg of oat herb extract acutely enhances these abilities among those with MCI, compared with placebo or 2400 mg. The number of errors made during the colour naming trial of the Stroop test reflects failures to inhibit task-irrelevant information. As such, this measure represents failures in attention, concentration and task focus. Results show that 1600 mg of oat herb extract reduced the number of errors made for all participants regardless of their cognitive status. These findings support the first indicative results in animals in which oat herb extract improved learning due to enhanced alertness and improved stress response in rats [3] and in humans [4]

The mechanism of effect remains unsubstantiated, however it has been suggested that green oat herb extracts have a significant inhibitory effect on monoamine oxidase B (MAO-B) and phosphodiesterase 4) (PDE 4) [8]. These results were determined in *in vitro* bioactivity assays with an extract concentration of 50 µg/ml. Inhibition of MAO-B increases dopamine levels which are associated with better cognitive functioning. Inhibition of PDE 4 improves the levels cyclic adenosine monophosphate (cAMP), which is important for neurotransmitter actions. In addition, inhibition of this enzyme is believed to be associated with increases in endothelium dependant vasodilatation in the cerebral arteries [9], but this is yet to be explored in humans. Therefore it is possible that the observed improvement in Stroop performance is due to enhanced neurotransmission and cerebral perfusion. Further research is required to determine the precise mechanism of action, as well as to gather more clinical data on the effects of this green oat herb extract in humans.

In conclusion, a 1600 mg oral dose of oat herb extract acutely improved attention, concentration and the ability to maintain task focus in older adults with differing levels of cognitive status.

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Disclosure Statement

No competing financial interests exist.

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Table 1. Stroop interference scores by supplement dose and MCI status *(data are expressed as mean ± SE).*

Supplement dose	MCI status	Mean	SE	N
0mg	MCI	3.12	0.47	7
	Non-MCI	2.28*	0.09	29
	Total	2.44	0.12	36
1600mg	MCI	2.30†	0.4	7
	Non-MCI	2.39	0.10	29
	Total	2.37	0.11	36
2400mg	MCI	2.89	0.31	7
	Non-MCI	2.31*	0.10	29
	Total	2.42	0.11	36

* = significant difference within dose between MCI and non-MCI ($p<0.05$), †=significant difference between 0mg and 1600mg in those with MCI ($p<0.05$).

MCI, Mild cognitive impairment, SE, standard error

Table 2: Errors on the Stroop colour-naming trial by supplement dose and MCI status *(data are expressed as mean ± SE).*

Supplement dose	MCI status	Mean	SE	N
0mg	MCI	9.00	3.0	7
	Non-MCI	2.13*‡	0.59	29
	Total	3.39	.083	36
1600mg	MCI	4.14†	2.5	7
	Non-MCI	0.55*	0.21	29
	Total	1.21#	0.51	36
2400mg	MCI	8.14	2.6	7
	Non-MCI	2.87*‡	0.64	29
	Total	3.84	0.77	36

* = significant difference within dose between MCI and non-MCI ($p<0.05$), †=significant difference between 0mg and 1600mg in those with MCI ($p<0.05$), #=significant difference from 0 mg and 2400 mg dose in the total group ($p<0.05$), ‡ significant different from 1600mg no MCI ($p<0.05$)

MCI, Mild cognitive impairment, SE, standard error